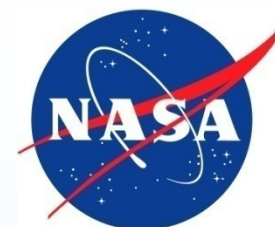


**NEPP Electronic Technology  
Workshop 2012**

National Aeronautics  
and Space Administration



# **Recent Power Metal-Oxide- Semiconductor Field-Effect Transistor (MOSFET) Test Results**

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# Acknowledgments

## Government:

- **Defense Threat Reduction Agency**
- **NASA/GSFC Radiation Effects and Analysis Group**
  - Ken LaBel, Ray Ladbury, Hak Kim, Anthony Phan, Megan Casey, Alyson Topper, Stephen Cox, and Tim Irwin
- **NASA/JPL**

## Industry:

- **Aeroflex**
- **Fuji**
- **International Rectifier**
- **Infineon Technologies**
- **Microsemi**
- **SEMICOA**
- **STMicro**
- **Texas Instruments**
- **Tower JAZZ**
- **Vishay Siliconix**



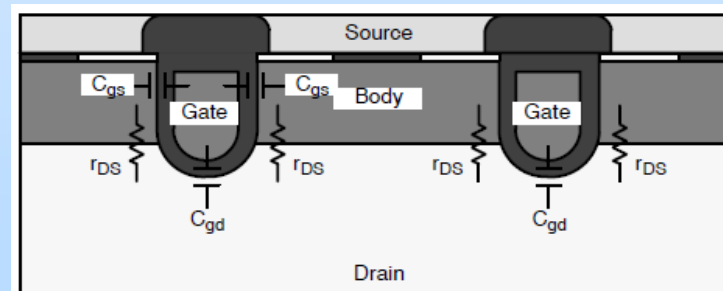
# Introduction

- **NEPP focus: Evaluate alternative power devices for space applications**
  - New technologies
  - New suppliers
- **This talk:**
  - Silicon power MOSFETs – part 1 (GSFC)
- **Other talks during this NEPP ETW:**
  - Silicon – part 2 (JPL)
  - Gallium Nitride
  - Silicon Carbide

# Vishay Commercial n-Type TrenchFET<sup>®</sup>



- Previous tests of Vishay commercial p-channel 12 V and 200 V TrenchFETs<sup>®</sup> showed good total ionizing dose (TID) and single-event effect (SEE) performance
  - Data presented at 2011 NEPP ETW
- **SUM45N25:**
  - commercial 250 V, 45 A, 0.058  $\Omega$  TrenchFET<sup>®</sup>
  - 175 °C junction temperature capability
  - $\pm 30$  V gate rating

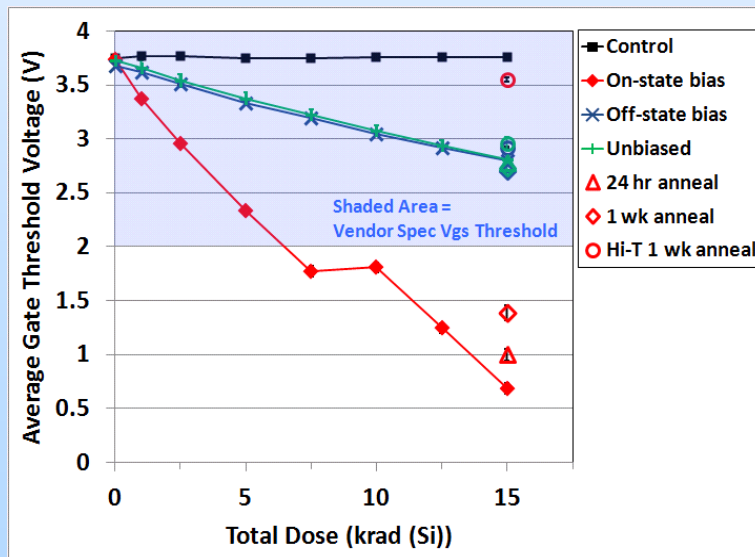


**Example TrenchFET<sup>®</sup> cross section.**  
*(From: Vishay Siliconix AN605)*

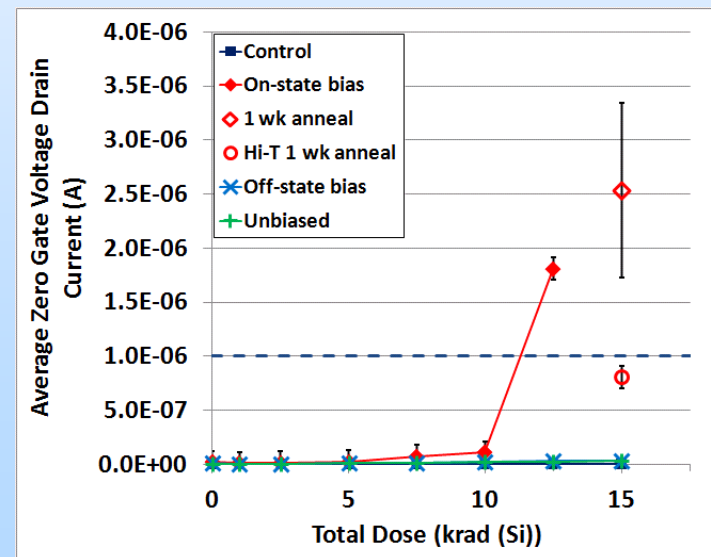
# Vishay SUM45N25 Commercial n-Type TrenchFET® TID Results



- **Bias conditions:**
  - On-state: gate-source voltage ( $V_{gs}$ ) = 18V; drain-source voltage ( $V_{ds}$ ) = 0V
  - Off-state:  $V_{ds}$  = 190V;  $V_{gs}$  = 0V
  - Unbiased:  $V_{ds}$  =  $V_{gs}$  = 0V
- **Dose rate:** 517 rad(Si)/min, with 2.62 rad(Si)/min overnight dose from 7.5 krad(Si) to 10 krad(Si) total dose steps

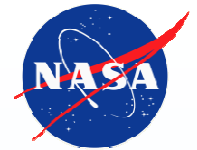


Gate Threshold Voltage

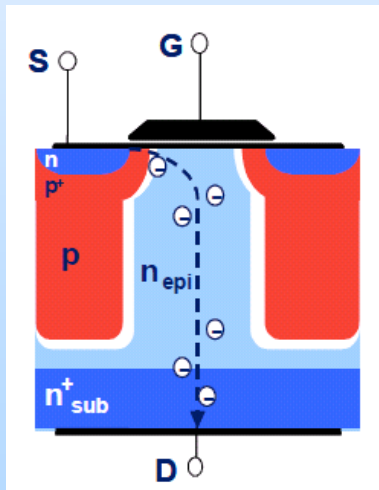


Drain Current at 0 V<sub>gs</sub>

# Infineon Radiation-Hardened n-Type Superjunction (SJ) MOSFET



- Infineon Technologies is first to develop a radiation-hardened version of a superjunction power MOSFET
  - Superjunction process should prove SEE-hardened:
    - Fields develop fairly evenly both laterally and vertically, reducing the peak field strength, thus impact ionization important for single-event burnout (SEB)
    - Reduced field strength + lateral fields reduce peak transient  $E_{ox}$  following an ion strike, important for single-event gate rupture (SEGR)



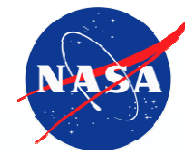
**Device tested: BUY25CS54A**

- 250 V, 54 A, 0.030  $\Omega$
- 100 krad(Si) rating

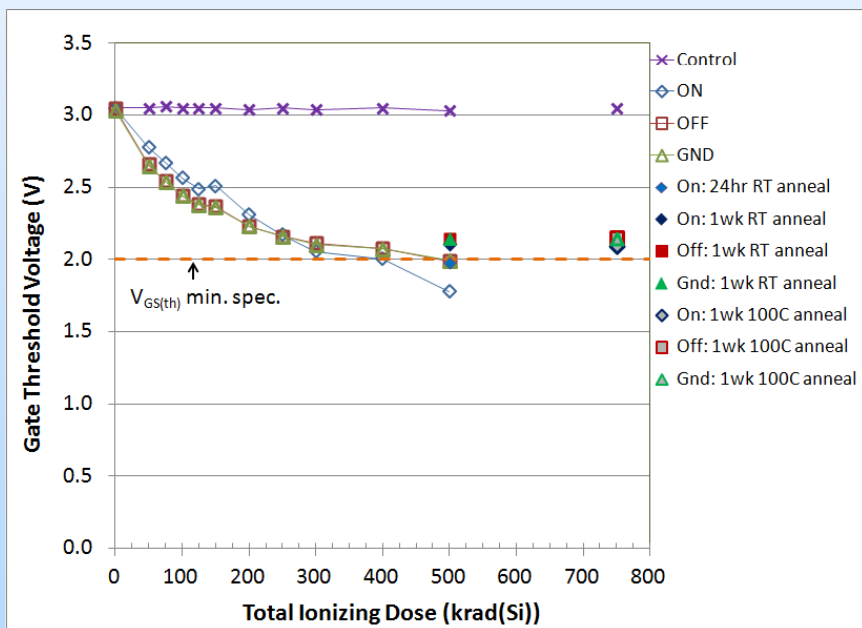
Example superjunction MOSFET cross section.

(Infineon Technologies Application Note AN-CoolMOS-CP-01)

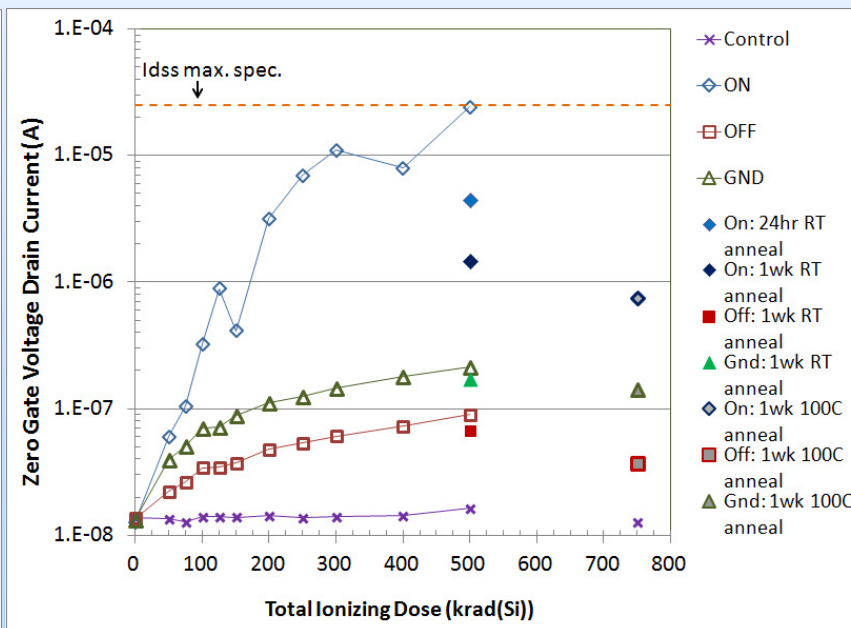
# Infineon BUY25CS54A n-Type SJ MOSFET TID Results



- **Bias conditions:**
  - On-state:  $V_{gs} = 12V$ ;  $V_{ds} = 0V$
  - Off-state:  $V_{ds} = 200V$ ;  $V_{gs} = 0V$
  - Unbiased:  $V_{ds} = V_{gs} = 0V$
- **Dose rate:** 940 rad(Si)/min with lower overnight rates



Gate Threshold Voltage



Drain Current at 0 Vgs



# SEE Tests

- **Planned this summer:**
  - Infineon 250 V SJ MOSFET (BUY25CS54A)
  - Aeroflex 250 V vertical MOSFET (VDMOS) (RAD7264)
  - Fuji 500 V VDMOS (JAXA-R-2SK4188)
  - SEMICOA -100 V p-type VDMOS (2N7425)
  - Vishay 250 V trenchFET® (SUM45N25)
  - Tower JAZZ 40 V lateral MOSFET (LDMOS) (test chip)

***Stay tuned for these and more test results!***